DOCUMENT RESUME

ED 413 062 PS 025 886

AUTHOR Kingma, Johannes; Tomic, Welko
TITLE On the Boundaries of the Acceleration of the Development of Intelligence.
SPONS AGENCY Open Univ., Heerlen (Netherlands).
PUB DATE 1996-07-00
NOTE 30p.
CONTRACT SW-3-96
PUB TYPE Information Analyses (070) -- Opinion Papers (120)
EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS Children; Compensatory Education; Developmental Tasks; *Early Intervention; Foreign Countries; *Intellectual Development; *Intelligence; Nature Nurture Controversy; Piagetian Theory; Preschool Education; Program Effectiveness; Theories
IDENTIFIERS Bruner (Jerome S); Piaget (Jean); Project Head Start

ABSTRACT

This paper examines the possibility of accelerating the development of intelligence when applying stringent Piagetian standards to evaluate the effects of short- and long-term intervention or instruction programs. The paper reviews previous Genevan and American research that shows that development can be accelerated by means of only a few long-term instruction programs that satisfy Piaget's criteria. Successful long-term intervention programs can be based on entirely different theoretical approaches, such as that of the Soviet Obuchova, the American preschool curriculum, or a paradigmatic training method. The only similarity in the different intervention programs is the systematic administration of the training tasks and the repetition of the exercises. However, despite the positive results of several intervention programs, even those of long duration such as Head Start, the effects diminish some time after the program has been discontinued. Studies of identical twins suggest that more permanent changes in the environmental factors influence the development of intelligence to a certain extent. A durable change in the development of intelligence may be invoked only if the environment in which the newly acquired skills have to be exercised has also changed more or less permanently. (Contains 56 references.) (Author/KB)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

On the Boundaries of the Acceleration of the Development of Intelligence

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)
X This document has been reproduced as received from the person or organization originating it.
☐ Minor changes have been made to improve reproduction quality.
• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

ED 413 062

Johannes Kingma
University Hospital Groningen

Welko Tomic
The Open University Heerlen

Running Head: Acceleration of Intelligence Development

This research was supported by a grant from The Open University, grant no. SW-3-96

PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL HAS BEEN GRANTED BY
W. Tomic
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

PS 025886

BEST COPY AVAILABLE

On the Boundaries of the Acceleration of the Development of Intelligence

ABSTRACT

Kingma and Tomic discuss the possibility of accelerating the development of intelligence when applying stringent Piagetian standards to evaluate the effects of short and long-term intervention or instruction programs. A review from previous research clearly shows that development can be accelerated (even in children who do not have any notion of the concept to be trained) by means of only a few long-term instruction programs that satisfy Piaget's criteria. Successful long-term intervention programs can be used based on entirely different theoretical approaches. The only similarity in the different intervention programs is the systematic administration of the training tasks and the repetition of the exercises. However, despite the positive results of the intervention programs, the effects will diminish some time after the program has been discontinued. The authors conclude that a durable change in the development of intelligence may only be invoked if the environment (context) in which the newly acquired "skills" have to be exercised has also changed more or less permanently.

On the Boundaries of the Acceleration of the Development of Intelligence

1 INTRODUCTION

The development of intelligence refers to the changes that an individual's mental apparatus undergoes due to experiences during his or her life cycle. According to Piaget, the development of intelligence takes place in a sequence of discrete stages. A child's way of thinking in one particular stage is qualitatively different than in the previous or subsequent phases.

With regard to intelligence, we can distinguish between cognitive structure and function. Cognitive structure is a hypothetical mental construct that changes throughout development. Function concerns the internal and external actions related to the structure.

The development of intelligence refers to a genesis of structures. Intelligence develops by refining and transforming mental structures (Piaget, 1963, 1964a, 1964b, 1973). Structure as defined by Piaget means an organized totality within which the relationships between elements are clearly defined. Cognitive structures refer to mental knowledge and production systems that are not directly observable but that lie at the basis of intelligent actions. In simplified form, a structure can be seen as a type of knowledge database that a child uses to interpret the world. The child knows the world or observes reality in terms of its structures. Piaget attempts to describe and explain the development of intelligence by postulating general abstract structures in which seemingly different intelligent actions might be arranged. Successive structures therefore differ qualitatively throughout the course of the development of intelligence.

Function concerns the internal and external actions related to the structure. Activating a cognitive process is an example of an internal action. For example, in attempting to recall

something, we are activating a series of internal actions that retrieve that particular word or concept from memory. Experience is the external aspect of function: it is the external source of stimulation.

Development is often viewed as the interaction between structure and function. Activities that take place both in the environment and in the structure itself can contribute to changes in the structure, which in turn bring about changes in the way the structure operates.

Piaget does not view the development of intelligence as a gradual accumulation of knowledge or skills, but rather as a sequence of structural transformations: rather abrupt, intermittent changes in the way a child thinks. During the transition between two stages, the child inhabits two qualitatively different worlds. The discrepancy between what things seem to be and what they really are leads to a conflict in the child's way of thinking. His thinking has progressed to a new and higher level and is now qualitatively different from his thinking based on the previous structure.

Another aspect of Piaget's theory is the notion that the activity of children is intrinsic. Their structures are intrinsically active, intrinsically curious. Children are not satisfied with what they already know, but are constantly in search of greater knowledge. The motivation to develop is generated from within. Although Piaget acknowledges that environmental and biological factors play a role, he considers intrinsic activity the motor of cognitive development. The fuel for this motor is the reciprocal relationship between function and structure, namely that the child's activity, or in reality the activity of the structures, influences the subsequent development of these structures. Intelligence develops as a result of the process of construction performed by the child. The child constructs his own reality. The child naturally interprets the information that reaches him from his

surroundings in terms of the information he already possesses. Development of intelligence means a change in both knowledge and ability. The database changes and consequently so do its structure and organization, and this alteration produces a change in how the child perceives reality.

According to Piaget, education must keep pace with the actual intelligence level of a child, so that the child can understand (assimilate) the new information. It is the conflict between the appearance of an object and what it actually is that in fact induces a change in the structure. The child's intrinsic activity and motivation together form the dynamic motor of the process that will lead to the resolution of such a conflict. The most suitable approach to learning is the method of self-discovery, in which the teacher remains in the background, offers suitable material at the appropriate time, and continuously asks questions that will encourage the child to justify his solutions. The teacher does not provide any feedback whatsoever.

Piaget is rather skeptical about the possibility of accelerating the development of intelligence through training or other interventions. Only children who already possess partial knowledge of the concept in which they are to be trained can benefit from training.

This chapter will review an important intelligence issue related to the Piagetian view. We will explore whether and if so, to what extent, the development of intelligence can be accelerated. This question is important in both theoretical and practical terms. The chapter concludes by discussing the different research results, and puts them into a theoretical perspective.

2 CAN THE DEVELOPMENT OF INTELLIGENCE BE ACCELERATED?

This section begins by describing the Genevan and American training studies. The discussion then turns to the various training methodologies and describes the attempts made to

accelerate the development of intelligence. Finally, the authors question why it is considered desirable to accelerate the development of intelligence.

2.1 Genevan Training Research

If adaptation is assumed to be a basic function of intelligence and of a child's self-regulating activity, one can understand Piaget's position on the possibility of accelerating the development of intelligence. The interpretation of Piaget's position can be described briefly in the following terms: "Readiness to learn". Not only should new subjects match the cognitive level at which a child presently functions, but learning itself should be embedded in the child's self-regulating activity. Wadsworth (1978) aptly describes this twofold condition in the following way:

> "The function of the teacher is not to accelerate the development of the child or speed up the rate of movement from stage to stage. The function of the teacher is to insure that development within each stage is thoroughly integrated and complete" (Wadsworth, 1978, p. 117).

Socio-educational transfer or instruction in knowledge and skills only makes sense when it links up with the cognitive structure that already exists. If we try to teach a child something that it is not capable of learning yet, it will probably be able to solve the problem it has been trained to solve, but no more than that. It will be unable to generalize enough to solve similar but slightly different problems, even after a period of instruction. The phenomenon of transfer, i.e., the ability to apply what one has learned in other training situations, does not take place (Kingma & TenVergert, 1993b, 1993c, 1993d).

For Piaget, it is precisely the range of the transfer which indicates whether instruction or training has brought about a fundamental change in a child's cognitive structure. If the child is unable to generalize, then training has in all

likelihood generated an isolated structure, so that the child is unable to use the principle it has learned to solve other problems.

Nonetheless, Piaget (1959a, 1959b) believes that it is possible to accelerate the development of intelligence by using certain specific instruction methods. That is only possible when instruction results in more complex cognitive structures being generated from simpler ones. Piaget therefore has a number of stringent requirements for both the method of instruction and the results achieved. Regarding the instruction method, the training methodology must correspond to the spontaneous development of intelligence (Inhelder, Sinclair, & Bovet, 1974). According to Piaget and his colleagues, the interview is the most suitable technique and, hence, the most important method of instruction, for example, for stimulating the construction principle (i.e., the manipulation of objects) in children.

> "By observing and interviewing children..., teachers gain empathy and respect for children's developing intellectual capacities. Such an understanding of their intellectual processes prevents the teacher from teaching children concepts they are not prepared to learn. In other words, this teacher is aware of the natural constraints of the child's stage of development. At the same time, the teacher has respect for the child's current capacity for learning and is aware of the multiplicity of new capacities that become available at each new level of development. This level of awareness alerts the teacher to curriculum materials that place artificial constraints on the children's natural capacities and provides her with a basis for making on-the-spot curriculum decisions in the classroom" (Labinowicz, 1980, p. 160).

The methodology described in this quotation demonstrates that instruction of training derived from Piaget's theory is viewed

as follows: during instruction, the child is given a range of objects to manipulate. When the child solves a problem the teacher or experimenter interviews the child, for example by asking: "Why is that so?" or "Do you think that's correct?" or "How do you know?". One of the fundamental principles of the Genevan method of instruction is that the child must discover the method of solution himself by manipulating objects. The self-discovery method, according to Piaget, is the most suitable way to teach or train intelligent actions, because it is a method that complements the child's own self-regulating activity. That brings us back to the starting situation or the child's actual cognitive level, which determines how successful instruction can in fact be. After all, children who are in a period of transition will experience a conflict between what <u>is</u> (direct observation) and what <u>might be</u> (it could be true). They will intrinsically be inclined to resolve that conflict themselves. The "<u>verstehend</u>" (empathic) capacity of the teacher or experimenter is of primary importance when it comes to creating situations for the child and offering the child the opportunity to resolve the conflict on his own.

It only makes sense to teach a new concept if the child already possesses partial knowledge of that concept. Children who are entirely unfamiliar with the concept will not benefit from training or instruction (Piaget, 1964a, 1964b). A child must first have the cognitive structure into which the new information can be assimilated.

> "This is why we cannot teach higher mathematics to a five-year-old. He does not yet have structures which enable him to understand" (Piaget, 1964b, p. 13).

Piaget's colleagues undertook numerous training experiments in the seventies in which they attempted to show that successful training depends on the child already having some understanding of a concept or of intelligent solution methods (Inhelder et al., 1974). In Piaget's opinion, a successful "learning

achievement" has to satisfy three requirements. First, the training or learning effect has to be evaluated from the perspective of the spontaneous development of intelligence. Second, there has to be evidence of transfer to conceptual areas in which the child has not been trained. For example, if the child has been trained to solve problems involving conservation of length, after training it should also be able to solve other, related problems, for example, involving seriation and transitivity of length. Finally, the learning effect has to be durable. The child should be re-tested on the problems listed under item 2 a few weeks to a few months (as many as four) later. If he is still able to solve these problems correctly even after a period of that length has passed, then training can be assumed to have been successful. Only if the three requirements are fulfilled, can one conclude whether training has induced a change in the child's cognitive structure.

The central issue of the second requirement is to convert the theoretical requirement into measurable terms. The general methodology of the Genevan school runs as follows. Prior to training, the children are administered a pretest in which they are asked to solve problems covering the subjects in which they are to be trained, for example conservation of length. Using Piaget's criteria, the children are, for instance, divided into non-conservers and partial conservers based on their solutions and arguments. The experimenter, also the instructor, then begins the training program. Usually, the instructor trains only one child at a time. The Genevan training approach is not standardized, as it takes place by means of the interview method described previously. In standardized training methods, all the children are given the same treatment according to a previously determined procedure. The Genevan training course generally lasts two to three sessions of fifteen to twenty minutes each. After training, each child is administered a

posttest which consists of problems that allow the researcher to assess the success of training, in accordance with Piaget's second requirement. The children's solutions to the posttest problems also indicate the range of transfer, which determines whether or not training has been successful. The child's score on the first posttest, administered immediately after training, is not the only determining factor, however. The "actual" level of intelligent action can be estimated. In a second, and even a third or fourth posttest, the children are asked to solve problems from the first posttest again, so that the durability of the learning and transfer effect can be determined. The results of Piaget's training experiments clearly show that children whose pretest indicates that they have no understanding whatsoever of the concept scarcely benefit from training, if at all (Inhelder et al., 1974). Even if the results of the immediate posttest show that the children have made some progress over the pretest results, there is still a very good chance that they will drop back to their old level by the time they take the second or third posttest.

The crucial question is whether it is possible to accelerate the development of intelligence in a durable way and at a higher level by means of instruction or training. The answer is yes, although with a few serious reservations. From the Piagetian perspective, the cognitive structure must be shaped in such a way that it can assimilate the new information. The possibility of acceleration is therefore restricted to those children who already have a partial knowledge or some notion of the concept in which they are to be trained. The training methodology must be based on the child's own self-regulatory function. In addition, there are stringent requirements with respect to the training effect. Piaget's training results show that short-term training will only accelerate the development of intelligence to a very limited extent. With this in mind, we may question whether it is indeed

generally possible to raise children to a higher level of intelligence through training. Piaget's position on this is rather pessimistic: short-term training is unsuitable. The following quote by Woolfolk (1987) is relevant here.

> "If you try to teach a student something the student is not ready to learn, he or she may learn to give the 'correct' answer. But this will not really affect the way the student thinks about this problem or any other problem. Therefore, from this perspective acceleration is useless. A second Piagetian argument is that acceleration is inefficient. Why spend a long time teaching something at one stage when the students will learn it by themselves much more rapidly and thoroughly at another stage" (Woolfolk, 1987, p. 70).

2.2 American Training Research

In the early sixties, a major dispute erupted specifically between the Genevan school and American researchers. The controversy was sparked by Bruner's (1960) The Process of Education, which focused on the issue of "Readiness to learn". Bruner disagreed with Piaget's idea that education had to keep pace with the child's actual cognitive level. In his view, it was precisely the task of education to anticipate that structure in order to stimulate cognitive development. Bruner influenced numerous American researchers, leading to a veritable boom in training experiments. These experiments focused largely on children who had not yet acquired any notion of the concept in which they were to be trained or of the solution method, for example non-conservers with respect to number, quantity, and so on. It is only a slight exaggeration to say that the researchers conducted extremely simple training experiments. While working on a conservation problem, for example, the experimenter would tell a non-conserver child "You can pour the water back, can't you?" or even demonstrate it. The posttest would then be administered, with the experimenter using orange juice instead of water, for example. Some training

sessions focused on only one problem, and the sessions sometimes varied from two to twenty or even forty minutes (Kingma, 1981). If we apply the three Piagetian criteria to the learning effects of the American training research, it becomes clear that these effects are relatively specific and short term, with only very limited transfer taking place. There was no research on durability. According to Kingma and Koops (1988), the American researchers' behaviorist background lay at the root of their unlimited optimism with respect to accelerating the development of intelligence in children who had not yet acquired any notion of the concept in which they were to be trained. Despite the very weak empirical evidence, the results apparently satisfied those researchers, but their findings do not support Piaget's theory on accelerating the development of intelligence by means of short-term training (Tomic, 1995a).

By now it has in fact been demonstrated that long-term training (i.e., lasting three to four weeks, during which, for instance, non-conservers and non-seriators receive fifteen to twenty minutes of training every school day) can generate massive training effects that meet Piaget's criteria and are observable for more than four months (Kingma, 1984b, 1986; Kingma & Loth, 1983, 1984; Kingma & Koops, 1984a, 1984b; Tomic, Kingma, & TenVergert, 1993). Long-term training can have a decisively positive impact on accelerating the development of intelligence.

2.3 Various Training Methods

It is important to note that various training methods are suitable. For example, Kingma (1986) constructed a training program on seriation based on the American preschool curriculum developed by Hooper and Marshall (1968) and Hooper (1973). Tomic et al. (1993) designed a training program on measurement based on a Soviet method developed by Obuchova (1966, 1972). The program applies the theoretical model of the stepwise

formation of mental action (Gal'perin, 1966) in a practical classroom situation. Tomic and Klauer (1996) have used a paradigmatic training method in studies focusing on inductive reasoning and problem-solving. These three programs, each of which was based on a different theory, accelerated the development of intelligence and met Piaget's stringent criteria for determining the success of training.

After the "success" of the American training studies in the sixties, Beilin (1971) came to the conclusion that every type of training program is effective when it comes to learning the concepts underlying Piaget's problems. His conclusion is drawn from other, and weaker, assessment criteria than those formulated by Piaget. When Piaget's stringent criteria are applied, more than 95% of the training studies in fact did not succeed in accelerating the development of intelligence (Kingma, 1981). The relatively small number of training programs whose results do meet Piaget's criteria are based on various theoretically founded theories of instruction. A theoretically derived methodology is evidently not the panacea which can accelerate the development of intelligence. On the contrary, more general aspects, present in every successful method, are decisive. In each successful method, the curriculum is constructed systematically. For example, suitable curriculum sequences are determined, the partial actions which underlie the training concepts are taught systematically, and regular repetition of these partial actions in various situations are spread out over a period of several weeks or more. The tasks or problems bring about a cognitive conflict in the child. The child has not acquired enough experience to solve the problem or to resolve the cognitive conflict. The child is hence guided in such a manner that a new, generally more complex cognitive structure arises. The scope of the transfer which has been generated is broad. Finally, an attempt is made to make the child aware of the new method of reasoning. This metacognitive

aspect is very important. These are features of successful methods that can also be found in Adey and Shayer (1995).

2.4 A Permanently Higher Level of Intelligence?

Over time a wide range of interventions have been applied in the form of training courses. Beilin (1971) and Kingma (1981) reported on many different small-scale experiments. Both researchers focused on what Piaget called "the American question": accelerating the development of intelligence through specific short training programs (Neimark, 1975). Large-scale training programs have been described and evaluated by Nickerson, Perkins and Smith (1985), Coles and Robinson (1989) and Nisbet and McGuiness (1990), and compensation and (school) enrichment programs of a similar scale, such as Head Start, have been described by Carter (1984), Nurss and Hodges (1982), and Scarr, Weinberg and Levine (1986).

The findings drawn specifically from small-scale experiments and experiments carried out within larger-scale training programs and, to a lesser extent, compensation and school enrichment programs, might lead to the optimistic conclusion that training and education are a relatively easy way of getting children to operate permanently at a higher level of intelligence. This optimism must be tempered somewhat, given the magnitude of the very long-term effects of both training and school enrichment programs. The key question is: after a successful course of training which also meets Piaget's criteria, what happens to the advantage that the trained children have over non-trained children if training is not continued at a higher level? After all, after the course of training ends, the child returns to its original environment in mainstream education along with the rest. After a while, for example a year, the non-trained children in the control group will progress "naturally" to the same level as the trained children. On the other hand, there is a chance that the trained children will drop down to the level of the non-trained

children once again.

We can illustrate the latter by looking at a successful method for teaching non-conserver children to solve conservation problems. The children are trained in measuring various quantitative aspects of objects, such as length, volume and surface area (Kingma & Loth, 1984; Tomic et al., 1993). The training programs induced strong and broad transfer effects, which continued to be observed four months after the training program had ended. These programs therefore more than satisfied Piaget's stringent requirements with respect to training success. After the training program, the trained children returned to their old classrooms. They were no longer given special training in specific measurement skills at a higher level. Two years after completing the training program, the performance of the trained children was slightly below that of two years before. What was striking was that the non-trained children had achieved approximately the same level as their trained classmates after two years. It appears that even without specific training, children are capable of learning concepts and solution strategies which allow them to solve problems taken from the training program accurately.

The results of very long-term training programs, some of which last from kindergarten to the final grade of primary school, also show that trained children enjoy a distinct advantage. The flip side of this remarkable success is that the majority of these children drop back down to the level of their untrained classmates after the extra training efforts cease. That is frequently also the result of social and psychological factors. This summary is based on reports on enrichment programs involving children from underprivileged socio-economic backgrounds, which were conducted in the sixties and seventies.

One of the most famous of these was the Head Start program, which focused on the theme "learning to learn":

"The curriculum usually included instruction in standard

English and the use of basic concepts. Children were taught to classify objects and events in terms of temporal and spatial relationships ('before' and 'after'; 'distant' and 'near'), size, color, and shape. They were taught to count. Some programs taught reading as well. Instruction was offered on an individual or small-group basis, and children were allowed to proceed at their own pace. Head Start centers were not like first-grade classrooms, but neither were they like home. Educators spent a good deal of effort instilling such habits as paying attention, listening to teachers, and following the rules" (Scarr, Weinberg, & Levine, 1986, p. 245).

The parents of participating children were involved in activities at centers which ran the pre-school training programs. The level of participation varied from one center to the next.

"The centers used a number of different models of parental involvement. Some programs were center based. In these, parents were informed about the program and, in some cases, participated in the planning; but they were not involved in daily activities. Other programs were home based. Here, 'parent educators' visited home; provided books, games and other materials for use in the home; and trained parents (usually mothers) in techniques for promoting cognitive development" (Scarr, Weinberg, & Levine, 1986, p. 245).

The children who participated in Head Start programs clearly did not always receive the same instruction and/or training. The volume and type of training, as well as the degree to which parents were involved, varied both within and between the various centers. The unsystematic design meant that it was impossible to find a clear-cut explanation for any positive effects on the development of intelligence.

After Head Start, which was launched in 1965, had been running for a few years, the results of various studies showed

that this type of education had a negative impact on the development of intelligence (Caruso, Taylor, & Detterman, 1982). Cicirelli (1969) showed that children who participated in the Head Start program did better at school than the control group of classmates, who had not had "preschool training". On closer analysis, however, it became clear that the advantage in terms of IQ and grades was relatively minor and that even those gains disappeared after two or three years in primary school. Other studies confirmed these findings (Scarr et al., 1986).

> "Compensatory programs appear to result in immediate gains which are greater for target children than for control children. These broad gains appear to dissipate over time, however, so that scores for control and experimental children approximate both one another and their pre-intervention scores after a few years in elementary school" (Nurss & Hodges, 1982, p. 50).

Other research demonstrated that compensatory programs like Head Start generally brought about short-term positive effects in better pupils (Carter, 1984). The effects of these programs are also biggest in the lower grades of primary school. Towards the end of primary school, however, any advantage acquired through a compensatory program has disappeared. Indeed, the training effect of long-term compensatory programs does not, in the long run, give even successful, gifted children a permanent advantage in the development of intelligence compared with classmates who did not participate in such a program.

Compensatory programs designed in the seventies and eighties were frequently criticized for not having clear-cut psychological and didactic underpinnings. Some "pre-school" curricula from that period were based on theoretical foundations, such as the "Piagetian Preschool Educational Program" (PPER). This program, implemented in the state of Wisconsin (USA), involved three- and five-year-olds in day

nurseries and kindergarten. Piaget's self-discovery method was one of the most important points of departure for the curriculum. Children were encouraged to actively manipulate objects and interact openly with their playmates. They were given neither correct solutions nor correct answers. For 28 weeks each school year, the children participated in a training session every school day. After three years, the participating children were evaluated. Compared with children in the control group who had not been trained, the trained children had made enormous progress on a whole series of Piagetian problems. Nevertheless, the control group children demonstrated similar progress (Hooper & De Frain, 1980, p. 172).

Weikart, Epstein, Schweinhant, and Bond (1978) showed that three different curricula, one of which was Piagetian, had the same effect on the development of intelligence. Although the three curricula were based on different theoretical foundations, these results showed that they had all successfully influenced the development of intelligence. Apparently, it is enough to systematically and regularly teach the relevant building blocks that will allow children to solve Piagetian problems. Even in cases where the curricula were more theoretically grounded, it became clear that without permanent follow-up after the training period had ended, the gains, in terms of accelerating the development of intelligence, were only temporary. Within a year or two, the non-trained children who continued their mainstream education were at the same level as the children involved in the experimental training conditions.

It could be stated, then, that a "long-term" training program lasting about four weeks is still too short to give the trained children a permanent advantage over their non-trained classmates in terms of their intelligence level. It should be noted that the criteria in that case are even more stringent than Piaget's.

The previous arguments make clear that the development of intelligence can be accelerated using specific training programs based on various curricula. The training effects of structured and long-term instruction appear to meet Piaget's stringent criteria with respect to training success. The fact that these positive training effects dissipate in the long run, a year or two after the training program ends, shows that a number of environmental factors must also undergo permanent change if the benefits are to last.

We might, for example, consider the results of studies on how the environment influences the development of intelligence in monozygote twins. Normally, genetically identical twins are raised together by their biological parents. There are cases, however, where each twin is adopted by a different set of parents. It might be said that the study of identical twins who were raised in different environments resembles an experiment in which the independent variable, the environment, has been manipulated (Van der Zanden, 1985). If we compare the intelligence test results of a set of identical twins who were raised separately to that of twins raised in the same environment, it becomes possible to determine the relative impact of the environment. Summaries of correlational studies on monozygote twins (Bouchard & McGue, 1981; Hunt, 1961; Vernon, 1979) show that the average correlation coefficient on an intelligence test is approximately .90 for identical twins raised in the same environment. For identical twins raised in different environments, on the other hand, the correlation coefficient is approximately .80.

> "If members of identical twin pairs had similar environments, these correlations may be interpreted as evidence that measured intelligence is at least partially determined by heredity. Related to these studies is the observation that with decreasing genetic similarity, there is a corresponding decrease in similarity between

intelligence scores" (Le Francois, 1984, p. 79). The difference in the strength of the correlation (.90 - .80 = .10) may be attributable to environmental influences, among other things. Environment does indeed have an impact on the development of intelligence, but the genetic component nevertheless predominates.

Within the context of Piaget's theory, the environmental effect on the development of intelligence can be described in terms of the processes which underlie adaptation, i.e., assimilation and accommodation.

2.5 Why Accelerate the Development of Intelligence

We are justified in questioning whether we should attempt to accelerate the development of intelligence if it turns out that children will acquire these concepts and solution strategies anyway, as part of a "natural" process of development, even if they do so later. The answer to this question can be broken down into three parts (Schmitt, 1994). First, human beings are persistent in their curiosity to know more. The question as to whether, and if so, to what extent the development of intelligence can be accelerated is simply an expression of this curiosity. Second, the idea of carrying out pioneering work, conquering unknown territory and surmounting barriers is irresistible. Third, the point is not only to acquire knowledge, but knowledge that can be applied. The application of this knowledge must also be generally useful. This is an urge whose roots go back to sixteenth-century Western European philosophy. Francis Bacon (1561-1626), the spiritual father of the credo "knowledge is power", described how the laws of nature, those which had been discovered and which had still to be discovered, could be manipulated by instruments and tools. Nature could be tamed and put to work in the service of man: technology. It is, hence, precisely the results of training experiment interventions that can help the educational psychologist and the educationalist to develop

instructional technology further.

> "The practical importance of modifying intelligence is more obvious but independent from theoretical importance. The degree to which intelligence is thought to be a biological characteristic in theoretical models has no bearing on the practical importance of its alterability. All interventions must be environmental. The development of a technology of education depends on exactly understanding to achieve gains in intelligence" (Detterman, 1982, p. VII).

The key question is whether the development of intelligence, as described in Piaget's theory, can be accelerated. The answer to the question is rather complex, but positive. Short training programs do not lead to a change in the cognitive structure and therefore do not induce an acceleration in the development of intelligence. On the other hand, long-term training programs do influence the development of intelligence. In the long run, however, a year or two after the program has ended, the positive effects dissipate. Studies of identical twins make clear that more permanent changes in the environmental factors influence the development of intelligence to a certain extent.

5 CONCLUDING REMARKS AND A LOOK AHEAD

Piaget's theory on the development of intelligence is related to the mental adaptation to new situations. A type of evolutionary process is repeated as the newborn develops into a young adult. After acquiring the formal operations, the person in question has all the cognitive tools he needs to be able to adapt to strongly fluctuating situations. Piaget bases his theory of stages, first of all, on observations of the behavior of very young children and secondly on the way in which children solve certain problems. The Piagetian tasks have an inherently theoretical reference point. Conservation tasks, for example, can help to determine whether a child is capable of reverse thinking within the conceptual area of the intended

conservation problem. The range within which the child can perform reversible operations is then determined by means of conservation problems which cover different conceptual areas such as quantity, weight, circumference, distance, area, volume, and speed.

The heated debate on the possibility of accelerating intelligence appears to have burned itself out. The enormous number of training experiments frequently resulted in the trained children making statistically significant progress compared with the control group. Most of this progress can be attributed to the low standard used to evaluate training success. However, when Piaget's more stringent standards are applied, the majority of training effects were not successes at all. The conclusion is that the development of intelligence can in fact be influenced, regardless of the theoretical underpinnings. But lasting change is only effected if the environment in which the newly acquired "skills" are to be exercised has also changed more or less permanently. Seen in that light, Piaget's adaptation theory becomes clear. A person in development adapts slowly to the changing situation.

We may assume that in the nineties, many developmental psychologists will refer to Piaget's theory. Further elaboration and refinement of his theory will have to wait, however, until the new flood of data on the development of the processes underlying Piagetian problem-solving tasks has been integrated into a coherent new theory at a higher level.

References

Adey, P., & Shayer, M. (1995). *Really raising standards*. Cognitive intervention and academic achievement. London: Routledge.

Bacon, F. (1626), (1901). *New Organon I*. New York: P.F. Collier & Son.

Beilin, H. (1971). The training and the acquisition of logical operations. In M.F. Rosskopf, L.P. Steffe, & S. Taback (Eds.), *Cognitive development research and mathematical education*. Washington, D.C.: National Council of Teachers of Mathematics.

Bouchard, T.J., & McGue, M. (1981). Familial studies of intelligence: a review. *Science, 212*, 1055-1059.

Bruner, J.S. (1960). *The process of education*. Cambridge: Harvard University Press.

Bruner, J.S. (1966). On the conservation of liquids. In J.S. Bruner, R.R. Olver, & P.M. Greenfield (Eds.), *Studies in cognitive growth*. New York: Wiley.

Carter, L.F. (1984). The sustaining effects study of compensatory and elementary education. *Educational Researcher, 13*, 4-13.

Caruso, D.R., Taylor, J.J., & Detterman, D.K. (1982). Intelligence research and intelligent policy. In D.K. Detterman, & R.J. Sternberg (Eds.), *How and how much can intelligence be increased*? Norwood, N.J.: Ablex Publishing Corporation.

Cicirelli, V. (1969). *The impact of Head Start: an evaluation*

of Head Start on children's cognitive and affective development. (OEO Report No PB 184 328) Westinghoun Learning Corporation for Federal and Technical Information. U.S. Institute for Applied Technology.

Coles, M.J., & Robinson, W.D. (Eds.), (1989). *Teaching thinking. A survey of programmes in education*. Bristol: Bristol Press.

Detterman, D.K. (1982). Foreword. In D.K. Detterman & R.J. Sternberg (Eds.), *How and how much can intelligence be increased*. Norwood, N.J.: Ablex Publishing Corporation.

Gal'perin, P.J. (1966). *A method, facts, and theories in the psychology of mental action and concept formation*. In Symposium 24: concept formation and inner action. 18th International Congress of Psychology, Moscow, p. 48-59.

Hooper, F.H. (1973). An evaluation of logical operations instruction in the preschool. In: K. Parker (Ed.), *The preschool in action: exploring early childhood programs*. Boston: Allyn & Bacon.

Hooper, F.H., & De Frain, J.D. (1980). On delineating distinctly Piagetian contributions to education. *Genetic Psychology Monographs, 101*, 151-181.

Hooper, F.H., & Marshall, W.H. (1968). *The initial phase of a preschool curriculum development project: final report*. Washington, D.C.: United States Department of Health, Education and Welfare, Office of Education.

Hunt, J.M. (1961). *Intelligence and experience*. New York: Ronald Press.

Inhelder, B., Sinclair, H., & Bovet, M. (1974). *Apprentisage et structures de la connaissance*. Paris: Presses Universitaires de France.

Kingma, J. (1981). *De ontwikkeling van quantitative en relationele begrippen bij kinderen van 4 tot 12 jaar.* [Development of quantitative and relational concepts in 4 to 12 year old children]. Lisse: Swets & Zeitlinger.

Kingma, J. (1986). The range of seriation training effects in young kindergarten children. *Contemporary Educational Psychology, 11*, 276-289.

Kingma, J., & Koops, W. (1984a). Seriatietraining bij kleuters. [Seriation training in kindergartners]. *Nederlands Tijdschrift voor de Psychologie, 39*, 234-244.

Kingma, J., & Koops, W. (1984b). Piaget en de relatie tussen onderwijs en ontwikkeling. [Piaget and the relation between education and development]. In B. Creemers (Ed.), *Onderwijskundig Lexicon*. 's-Hertogenbosch: Samson.

Kingma, J., & Loth, F.L. (1983). Het trainen van seriatie volgens de methode van Levinova bij jonge kinderen. [Seriation training in young children according the Levinova method]. *Psychologica Belgica*, 23, 1-16.

Kingma, J., & Loth, F.L. (1984a). Effects of perceptual manipulations on number comparison tasks. *International Journal of Behavioural Development*, 7, 21-33.

Kingma, J., & Loth, F.L. (1984b). The development of relational terms in different concept areas. *The Journal of General*

Psychology, 111, 163-175.

Kingma, J., & TenVergert, E.M. (1993a). Het ontwerpen van transferstudies. [Designing transfer studies]. In W. Tomic, & P. Span (Eds.), *Onderwijspsychologie: beïnvloeding, verloop en resultaten van leerprocessen*. Utrecht: Lemma.

Kingma, J., & TenVergert, E.M. (1993b). Leertheoretische en cognitivistische interpretaties van transfer. [Learning theoretical and cognitivistic interpretations of transfer]. In W. Tomic, & P. Span (Eds.), *Onderwijspsychologie: beïnvloeding, verloop en resultaten van leerprocessen*. Utrecht: Lemma.

Kingma, J., & TenVergert, E.M. (1993c). Transfer: oefening baart kunst. [Transfer: practice makes perfect]. In W. Tomic, & P. Span (Eds.), *Onderwijspsychologie: beïnvloeding, verloop en resultaten van leerprocessen*. Utrecht: Lemma.

Labinowcz, E. (1980). *The Piaget primer: thinking, learning and teaching*. Reading, MA.: Addison-Wesley.

Le Francois, G. (1984). *The lifespan*. Belmont, CA.: Wadsworth.

Weimark, E. (1975). Intellectual development during adolescence. In F.D. Horowitz, (Ed.), *Review of child development research*, vol.4. Chicago: University of Chicago Press, pp. 541-594.

Nickerson, R.S., Perkins, D.N., & Smith, E.E. (1985). *The teaching of thinking*. Hillsdale, N.J.: Lawrence Erlbaum Associates.

Nisbet, J., & McGuiness, C. (1990). Teaching thinking: The European scene. *Teacher thinking and problem solving, 12, 3,*

12-14.

Nurss, J.R., & Hodges, W.L. (1982). Early childhood development. In H.E. Mitzel (Ed.), *Encyclopedia of educational research*. New York: MacMillan.

Obuchova, L.F. (1966). *Experimental formation of representations of invariance in five- and six-year-old children*. In Symposium 24: concept formation and inner action. 18th International Congress of Psychology, Moscow. pp. 103-108.

Obuchova, L.F. (1972). *Etapy razvitija detskogo myslenija*, [Development of thinking in children]. Izdatel' Stvo Moskocvskogo. Utrecht: Rijksuniversiteit, Psychologisch Laboratorium.

Piaget, J. (1959a). *Apprentissage et connaissance. Etudes d'Epistémologie Génétique, tome 7*. Paris: Presses Universitaires de France.

Piaget, J. (1959b). Apprentissage et connaissance. *Etudes d'Epistémologie Génétique, tome 10*. Paris: Presses Universitaires de France.

Piaget, J. (1963). Le problème de la filiation des structures. [Problem of structure association]. *Etudes d'Epistemologie Genetique, Tome 15*. Paris: Presses Universitares de France.

Piaget, J. (1964a). Development and learning. *Journal of Research in Science Teaching, 2*, 176-186.

Piaget, J. (1964b). Development and learning. In R.E. Ripple, & V.N. Rockcastle (Eds.), *Piaget rediscovered: a report of the conference on cognitive studies and curriculum development*.

Ithaca, School of Education: Cornell University.

Piaget, J. (1973). La psychologie de l'intelligence. [Psychology of intelligence]. Paris: Colin 2nd edition (1st edition 1947)

Piaget, J. (1974). *Adaption vitale et psychologie de l'intelligence*. [Adaptation and psychology of intelligence]. Paris: Hermann.

Piaget, J (1975a). *La naissance de l'intelligence chez l'enfant*. [The emergence of intelligence in the child]. Neuchatel: Delachaux et Niesle. 8de druk (1e druk 1936).

Piaget, J. (1975b). L'Equilibration des structures cognitives: Probleme central du devolppement. [Equilibration of cognitive structures. Central problem of development]. *Etudes d' Epistemologie Genetique, 33*. Paris: Presses universitaires de France.

Piaget, J. (1976). *Le comportement moteur de l'evolution*. [Motor behavior of evolution]. Paris: Gallimard.

Scarr, S., Weinberg, R.A., & Levine, A. (1986). *Understanding development*. New York: Harcourt Brace Jovanovich.

Schmitt, R. (1994). *Searching for Harmony*. Washington, DC: National Academy of Sciences.

Tomic, W. (1995a). Reikwijdte van transfer van een training in inductief redeneren. [Range of transfer of a training in inductive reasoning]. *Pedagogisch Tijdschrift, 20*, 341-351.

Tomic, W. (1995b). Training in inductive reasoning and problem

solving. *Contemporary Educational Psychology, 20,* 483-490.

Tomic, W., Kingma, J., & TenVergert E.M. (1993). Training in measurement. *Journal of Educational Research, 86,* 340-348.

Tomic, W., & Kingma, J. (in press). On the relationship between seriation and number line comprehension.

Tomic, W., & Klauer, K.J. (1996). On the effects of an inductive reasoning training: How far does it transfer and how long do the effects persist? *European Journal of Psychology of Education,* 283-299.

Van der Zanden, J.W. (1985). *Human development.* New York: Knopf.

Vernon, P.E. (1979). *Intelligence, heredity and intelligence.* New York: Freeman.

Wadsworth, B. (1978). *Piaget's theory of cognitive development: an introduction for students of psychology and education.* New York: McKay.

Woolfolk, A.E. (1987). *Educational Psychology.* Englewood Cliffs, N.J.: Prentice Hall.